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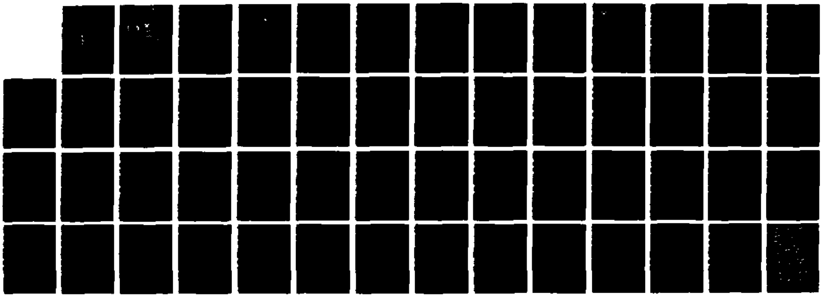

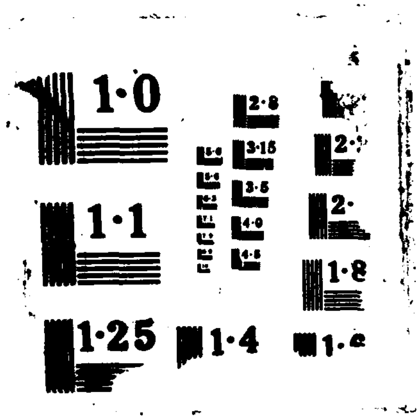
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AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

TECHNOLOGY TRANSFUSION -
A NETWORK RECOMMENDATION

MAJOR GREGORY F. PADULA 88-2030

"insights into tomorrow"

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Submitted to the faculty in partial fulfillment of
requirements for graduation.

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This report verifies technology transfusion (the moving of high-payoff low-risk technologies from their first application to subsequent ones) takes too long and recommends several means to accelerate it. The recommendations were deduced by examining how six impediments to transfusion can be partially overcome using some of the over 20 organizations/processes that are briefly described in the report. The primary recommendation of the report is the chartering and manning of an organization to advocate and link (integrate) transfusion efforts across the Air Force using a networked approach. This approach can provide a synergistic effect to the transfusion process by providing structure in a decentralized fashion, guided, when needed, by a central organization that is "in charge."

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PREFACE

The United States depends on technology to overcome the numeric superiority of the threat; yet, we often do not move technology from the first application to subsequent ones (transfusion) in a timely manner. Consequently, we have billions of dollars in technology "sitting on the shelf," while our operators and maintainers in the field make do with what they have. This paper will define and scope the transfusion problem (Chapter 1), describe some of the impediments (Chapter 2) as well as the expediters of transfusion (Chapter 3), it will then analyze the impediments in light of what is available in order to make some recommendations (Chapter 4), and finally it will draw a conclusion and summarize the recomendations (Chapter 5). This paper can be used as a beginning in understanding technology transfusion and how to accomplish it. Additionally, specific recommendations will be made to improve the process.

I would like to express a special thanks to several people for their help in the preparation of this report.

First, I would like to thank my family for their understanding and support.

Next, I owe a debt of thanks to all I interviewed but especially to Lt Col Donald Potter and my sponsor, Col Richard Ennis.

Finally, I would like to thank my faculty advisor, Maj (Lt Col select) Tom Hall for his pertinent guidance in keeping me "on track."

ABOUT THE AUTHOR

Major Gregory F. Padula was born in May 1950 in Rome, New York. He graduated from Jesuit High School in Shreveport, Louisiana and received his Bachelor's of Science in Electrical Engineering from Louisiana Tech University in 1973. In 1984 he graduated from the Air Force Institute of Technology (AFIT) with a Master of Science in logistics management.

In March 1973, he entered active duty and pilot training at Columbus AFB, Mississippi. From 1974 - 1977 he trained foreign officers as a T-37 instructor pilot in the Security Assistance Training Program at Sheppard AFB. During this tour he spent time as squadron safety and standardization officer as well as wing computer and life support officer.

From November 1977 to October 1982, Major Padula served in the 438th Military Airlift Wing at McGuire AFB, New Jersey as aircraft commander and instructor aircraft commander. For two years he served as wing command post duty officer and flightline expediter. His last year at McGuire was as Wing Airlift Director.

Major Padula moved to Wright-Patterson AFB, Ohio and served as Chief of the Integration Office for Aeronautical Programs, the Air Force Acquisition Logistics Center, from 1982 until he was selected for AFIT in June 1983. As a distinguished graduate from AFIT in 1984, he received the General Rawlings award for leadership and academic excellence, the Pride and Excellence Award for his thesis, and the SOLE Professional Designation in Logistics, as well as nominations for Sigma Iota Epsilon (a national honorary and professional society) and Alpha Iota Delta (an honorary decision support society).

In October 1984, he became a logistics management officer in the Plans and Programs Division of the Air Force Coordinating Office for Logistics Research (AFCOLR). In January 1985, he became chief of that division, assuming duties that included: Air Force Long Range Planning Team, Air Force Logistics Long Range Planning Team, and Logistics RDT&E Panel of the Joint Logistics Commanders, as well as responsibility for technology awareness, analysis, ADP, administrative, and budgetary branches.

In August 1987, Major Padula began his present assignment as a student at Air Command and Staff College.

He is a senior pilot with over 3,000 flying hours including over 1000 instructor hours.

Major Padula is married to the former Effie Grant of Houston, Texas. They have two children: Amanda and Dawn.

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AUTHOR(S) MAJOR GREGORY F. PADULA, USAF

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I. Purpose: To verify technology transfusion takes too long and if so to recommend some means to accelerate it.

II. Problem: How can the technology transfusion process be accelerated to increase combat capability for relatively low-risk high-payoff technologies? This problem is particularly significant since we rely on technology to overcome the numeric superiority of the threat.

III. Data. There is overwhelming data supporting the premise that the transfusion process is too slow, 9-15 years for most technologies. The analysis, conclusions, and recommendations of this report were based on literature on the subject, the opinion of several experts in the field who work with the process on a daily basis, and the author's background.

This problem is one that needs reviewing in that there are few studies aimed at improving the transfusion process, that is, the movement of technology from its first application to other Air Force systems. There are many studies on transferring technology to the Soviets, transitioning technology from the laboratories into a single systems, and transfusing technology from the government to industry, but none were found on transfusing technology through the Air Force.

Chapter 2 identifies six major impediments to transfusion: undocumented requirements, lack of information, lack of incentives/perceived high risk, lack of funding, resistance to change, and insufficient linkage/advocacy. Undocumented requirements especially in the program management directives (PMDs) and the statements of work (SOWs) of the various contracts often force the decision makers to choose the least expensive technology that meets the documented requirements and therefore not chose the candidate technology lest he lose the contract. Lack of information concerning what technologies are available, what their benefits are, and what risks are involved was the most cited reason as a transfusion impediment. Lack of incentives/perceived high risk relates to a host of questions concerning both the risk one must take if he is to transfuse the technology (negative incentive) and the missing positive incentives that motivate one to change things. Lack of funds, from either internal or external sources, will stop a technology from being inserted. Resistance to change even though the technology has been demonstrated is cited as the most significant reason technology does not transition according to a 1986 study. The final impediment listed, insufficient linkage/advocacy, if overcome can help break each of the individual barriers through advocacy as well as create tremendous synergy by linking the various efforts.

Chapter 3 highlights several organizations/processes that can be used to expedite the transfusion of technology. They are arranged by those that: plan, document requirements, identify technology, reduce risk through validation, fund, and link/advocate technology. A brief overview of approximately 20 organizations/processes with some of their points of contact are given to provide the reader with background on how to transfuse technology.

IV. <u>Conclusion</u> This report concludes that the transfusion of high-payoff low-risk technology is too slow but can be accelerated. Recommendations to accelerate transfusion were deduced by examining how the impediments to technology transfusion can be partially overcome with existing expediters. These expediters include many organizations and processes that can be used for transfusion but were designed for other purposes. One can accelerate technology transfusion by understanding, linking, and using existing processes; however, if one wants to capitalize on mature technology in a much more effective way, he should network the existing processes/organizations into a decentralized whole, guided, when needed, by a central organization that is "in charge." The synergistic interaction of the players, guided by this central organization will more than pay for the money and the manpower invested to transfuse technology.

V. <u>Recommendations:</u> The primary recommendation from this report is the chartering and manning of an organization to advocate and link (integrate) transfusion efforts across the Air Force using a networked approach. This organization will work within the existing processes/organizations as much as possible. Consequently, each organization that is key to transfusing technology should become a node in that network and chartered and trained to perform those functions.

Additional recommendations include: defining "transfusion," "transfer," and "insertion" in JCS Pub 1 and disseminating to industry; making the other services' nodes in the transfusion network; considering contracting out part of the network's functions, similar to NASA's Technology Utilization Program; developing a "TECHFUSION" list, similar to AFSC "TECHINSERT," to provide a compendium of low-risk high-payoff technologies ready for insertion; developing technology transfusion plans from a validated list of technology candidates; and considering making technology transfusion funds self generating using either a revolving fund or a contractor.

Chapter 1

INTRODUCTION

Why did it take the Air Force over 14 years to accept a technology that provides leak free hydraulic fittings? There were 350,000 of these fittings flying on Navy F-14 aircraft, for 14 years--with no leaks. This performance is even more impressive when you consider that these fittings were exposed to both the stresses of a fighter environment and corrosion problems of the salt spray on a carrier (45:--). The implications of this Air Force "oversight" are tremendous in peacetime, but could be critical in wartime. In the dispersed wartime environment, the time, manpower, and parts it takes to repair the system will probably not be available.

Transfusing technology to the field takes too long, often from 9 to 15 years according to acquisition experts (34:--; 41:--; 44:--; 46:--; 47:--; 52:--; 55:--; 56:--; 60:--). In the meantime, our combat capability is reduced, our life cycle costs are often higher, and our operation and maintenance budget increased. Why did this take so long and can something be done about it? The answers to these types of questions are subjects of this study.

This report will show there is a problem with technology transfusion and why that is important (Chapter 1), describe some of the impediments to technology transfusion (Chapter 2), describe some of the expediters of transfusion (Chapter 3), analyze and make recommendations on how impediments may be overcome using some of the expediters (Chapter 4), and finally, draw some conclusions (Chapter 5).

This chapter provides a description of the problem, the documentation of the problem, and significance of that problem, as well as the scope and significance of the report. The rest of this report provides information for the reader to use to better understand, utilize, and improve the current technology transfusion process.

PROBLEM

This study will address how technology transfusion can be accelerated to increase combat capability for high-payoff relatively low-risk technologies.

Before addressing the problem or its solution, one must understand what is meant by "technology transfusion," "high payoff," and "low risk."

"Technology transfusion," for the purpose of this report, is the insertion of a technology on one or more systems once it has been proven in an initial application. Transfusion, transition, transfer, and insertion are sometimes used interchangeably. Transition is often referred to as the "vertical" movement of technology from a laboratory to a system. "Transferring" and "transfusing" both refer to the "horizontal" movement of technology from one system to another. Though "transfer" sometimes has the positive connotation of moving technology from the federal sector to the private sector and state and local governments, the term will be avoided because of the negative connotation it has of of moving technology from the United States to the Soviets. This report will use "transfusion" to describe the beneficial horizontal movement of technology to one or more systems after its initial application. "Insertion" will be used to describe the movement of technology into a particular system.

"High-payoff" technologies are those that can provide significant increases in combat capability for the cost. This includes not only technologies that increase the traditional performance factors such as, speed, payload, and range; but also, nontraditional ones such as, reliability, maintainability, and sustainability. The payoff determination must be examined in light of the operational environment. For example, is the need for a reliable and maintainable technology, in a dispersed operational environment, a luxury or a requirement?

Another term that needs defining in the problem statement is "low risk." For the purpose of this report, low-risk technologies are those that have been proven on at least one system or subsystem and hence, pose little risk that they will be unsatisfactory in a new application.

DOCUMENTATION OF THE PROBLEM

The view that transfusing high-payoff low-risk technology takes too long has been expressed by the technical community, the literature, by example, and by those that are working the problem every day. The problem was acknowledged by the technical community during a 1986 DOD sponsored technology transition/transfusion meeting. The meeting of over two hundred engineers and scientist concluded, "As soon as the owners are willing to pay for the innovation and designers are willing to allow it, contractors are willing to risk it (8:1)." Basically, the contractors recognized there were impediments slowing the transfusion of technology but claimed it was not their problem but one with the government in not providing the money and "go ahead."

The literature also supports that transfusion takes too long because of various impediments. These include undocumented requirements (30:--), insufficient information (29:ii,33-34,48; 13:20,49,89-92), perceived high risk (36:20,68,70), lack of funds (30:8), resistance to change (29:30-31,37; 36:47), and insufficient advocacy/linkage (29:38-39,47-48). These impediments will be covered in more detail in Chapter 2.

A good way to illustrate the problem is through examples. Why did it take 14 years to introduce leak free hydraulic fittings in the Air Force inventory and then why was it only introduced as a repair procedure? It was by chance that the Air Force even discovered this technology during an Air Force Coordinating Office for Logistics Research (AFCOLR) Blue Two Visit (BTV). In the BTV program Air Force NCOs take senior industry and government design engineers and program managers to the operational environment and have them learn directly from the maintainers in the field. An NCO at a Navy facility explained how pleased he was with the hydraulic fittings on the F-14. Further investigation revealed there had been no leaks on the fittings even though there were over 350,000 of them flying for over 14 years. With this information AFCOLR spent 9 months bringing the using, acquisition, engineering, and technology communities together. Though excitement was generated in the using community, there were several obstacles to transfusion, including lack of information, resistance to change, and a MIL-SPEC that had to be changed or waivered. Finally, with the "pushing" of a general officer and significant amount of follow up activity by other organizations, the technology was accepted by some. This effort did payoff as it is now being used as a standard fitting on such aircraft as the C-5B and B-1B (45:--).

Another example is that of carbon-carbon brakes. Though proven on the F-15 in 1971, they were not used on the F-16 C/D as original equipment. In the early 1980s, as a result of management support and a Value Engineering (VE) effort, the F-16 C/D received the better carbon brakes (34:--).

Probably the most significant indication of a problem in transfusion is the testimony from the experts that work with technology every day. All experts interviewed pointed out the process was <u>too slow</u>, taking 9 to 15 years for most technologies (34:--; 41:--; 44:--; 46:--; 47:--; 52:--; 55:--; 56:--; 60:--). Reasons for the slow transfusion will be included in the next chapter.

This section has shown the problems in technology transfusion are widely recognized. The next section will describe what areas this report will focus on and why.

SCOPE OF THE REPORT

The scope of this report will be limited to the transfusion of reliability, maintainability, and supportability (RM&S) low-risk technologies and will cover only some of the organizations that enhance transfusion of technology into new and existing systems. Even though the report focuses on RM&S technologies, the analysis and most of the recommendations could be used for other technologies. RM&S technologies are the focus, not to suggest that they are an end unto themselves, but rather have been neglected for their contribution to combat capability. Low-risk technologies were chosen because they often eliminate one of the major obstacles to transition, high risk, while still maintaining a plentiful source of technologies (see next section for more detail).

The results of the report may be applied to the transfusion of technology in both developing and existing systems. It will apply especially to existing systems as they represent 75 - 80 percent of the systems we will have in the inventory in the year 2000 (40:--).

Within these limits, this report should offer a source of information for the reader and, if the recommendations are implemented, benefits for the Air Force. The significance of these benefits are explained in the next section.

SIGNIFICANCE OF THE REPORT

The report is significant to the extent it can be used to better utilize the technology available to increase combat capability and reduce cost. This is especially significant considering the quantity of technology available and our dependence on technology at the national level to meet the threat.

The quantity of this technology is significant, especially considering that there are 14 laboratories in the Air Force and over 70 in DOD (7:200). In 1982 the Assistant Director for Research, Office of the Deputy Under Secretary of Defense, estimated the total R&D for the US in that year to be $ 70 billion to $ 80 billion, of which $ 40 billion was in the government and $ 20 billion was in the DOD budget (7:196). In 1986 DOD figures were just slightly lower, at $ 18 billion (10:11). It can be seen that there is a significant amount of money spent on research and development which, most will agree, is producing significant available technology. The problem lies in determining how to make use of that technology. The Japanese were able to reap $15 billion through the purchase of $1.5 billion in United States technology (4:99). Gee points out we have the same opportunity to take advantage of American technology but we do not do it very well (4:99-100). The

objective of this report is to help the Air Force better exploit the technology available to improve our combat capability.

Facilitating insertion of low-risk high-payoff technology will increase combat capability mainly in two ways. First, technology can improve the technical performance of a system, giving the operator the speed, payload, and range he may need to win an engagement. Second, technology can increase reliability, maintainability, and supportability (RM&S), and therefore, make the systems more available and sustainable which in turn increases effective sortie rates and reduces operating cost. Increased sortie rates effectively increase the number of aircraft that can engage in combat. Decreased operating cost enables us to buy more systems. Even a small percentage decrease in the Operations and Maintenance (O&M) requirements can be significant if one considers that 24 percent ($24.8 billion) of the FY 88 Air Force budget is O&M and of that, 85 percent is fixed by the technology of the system (24:820). Since cost is so dependent on technology, there is a great opportunity to save money by using low-risk high-payoff technologies. One organization, which will be covered in Chapter 2 (PRAM), has already demonstrated greater than a 5:1 five year return for every dollar invested, with some returns greater than 20:1 (39:--; 43:--). If one considers life cycle savings returns jump to an average of 25:1 (59:--).

This tremendous return from technology supports our national objectives. The Secretary of Defense's Annual Report to Congress stated the United States relies on technologies as "force multipliers" to enable us to "fight outnumbered and win (25:245-246)." The US Military Posture for 1988 reinforces this point then goes on to say that we need to field our technologies in a "timely manner (51:10)." As the means to accelerate high-payoff low-risk technology are increased, the better we can take advantage of the significant amount of technology available to increase our combat capability to meet the threat and support our national objectives.

CHAPTER CONCLUSION

This chapter has shown technology transfuses through the Air Force too slow, 9 - 15 years on the average. This is supported by many sources to include the technical community, the literature, examples, and experts currently working in technology. Furthermore, this chapter has shown it to be significant in view of the quantity of technology available and how we depend on it to overcome the numeric superiority of the threat. Armed with this background, the next chapter will help answer why the problem exists.

Chapter 2

TRANSFUSION IMPEDIMENTS

While Chapter 1 pointed out there is a problem and that it is significant, this chapter will describe some of the major causes of the slow transfusion as found in literature and confirmed by experts (34:--; 41:--; 44:--; 46:--; 47:--; 52:--; 55:--; 56:--; 60:--). These impediments include: undocumented requirements, lack of information, lack of incentives/perceived high risk, lack of funding, resistance to change, and insufficient linkage/advocacy.

UNDOCUMENTED REQUIREMENTS

If the requirement is not documented in the Program Management Directive (PMD) or the Statement of Work (SOW), the chances are small the technology will be used. The National Academy of Engineering Committee on Technology Transfer and Utilization found requirement documentation necessary and listed it as their third step to transfuse technology (30:7).

Industry confirmed this finding in 1984, in the preparation of the Air Force document "R&M 2000." Interviews with 30 industry leaders revealed that if one wants a requirement included on a system, it should be documented in the PMD and other contractual documents, such as, the SOW (38:4,7).

The requirement can be documented using either performance specifications or by specifying the technology. Specifying insufficient performance levels can impede the transfusion of technology by almost forcing the contractor to select the least expensive technology that meets the specifications. If a contractor opts for a more expensive technology, he may lose the competition regardless of the benefits.

In a more direct manner, specifying a technology, prevents a technology from being overlooked or the process from being suboptimized. According to Schoderbek, suboptimization occurs when a decision maker opts to fill personal goals at the expense of system goals for such reasons as increased profit and reduced risk (6:246-247). On the other hand, specifying a technology has

the drawback of restricting the decision maker from searching for and choosing a better technology.

LACK OF INFORMATION

It is clear, if a decision maker does not know a technology is available, he will not use it; however, more often the problem lies in lack of information regarding the risks and benefits of the technology. This lack of information is considered by many to be the largest problem with technology transfusion. The overall conclusion of Mullis is "the key to effective transition is good communication and extensive interactions among the researchers and the users of technology (29:ii,33-34,48)."

In hearings before the Subcommittee on Science, Research, and Technology, the Chief, Technology Sharing Division of the Office of the Assistant Secretary of Transportation said, "information exchange is the basis for technology sharing (13:20)." The Deputy Assistant Secretary of Commerce for Science and Technology later testified that communication between the parties involved could solve many of the transfusion problems (13:49).

In those same hearings, NASA reported on their Technology Utilization Program and explained how it is centered around information flow. The elements of their program include publications that report technology developments; "application teams," to identify problems that technology can solve; a network of Industrial Application Centers for users to obtain information; and finally, application projects to validate the technology (13:89-92). The Air Force does not have any program near this scope, yet, we have similar requirements for technology.

The Committee on Technology Transfer and Utilization of the National Academy for Engineering lists "publishing and disseminating the R&D information" as the second step to transfuse technology (30:7). The report then advocated this role be more active when it went on to say,

> The methods generally used by federal agencies for transferring technology involve passive techniques ... [that] are not fully effective because they depend upon: the ... user to define the technology he seeks; the procedures used to search and identify the requested information; the format in which the data is provided to the requester; as well as the the skill of the user in assimilating the knowledge, evaluating its relevance, and adapting the technology to meet the specific need (30:11-12).

Finally, recent expert opinion confirmed the problem still exists. At a conference in September 1987, Brigadier General Dempsey, as the representative of the using community, said that awareness was a major problem with technology transfusion (40:--). It is clear user centered active information flow is required for transfusion, but that is not enough. Without proper incentives or if there is too much perceived risk, the technology probably will not transfuse.

LACK OF INCENTIVES/PERCEIVED HIGH RISK

Insufficient or negative incentives can slow or stop a technology from transfusing. Each link in the transfusion process may need additional incentives. Why should an organization that has inserted a technology on their system use their money and manpower to help people in another command? Why should an organization fund technology if they never realize any returns for their efforts? Why should a Program Manager (PM) or System Program Manager (SPM) use a new technology that may cause them to do a poorer job on the items they are rated on, such as cost and schedule? Why should a contractor use a different technology, that will increase his risk, if its not required and he is on a firm fixed price contract? Why should a PM, SPM, or a contractor try to insert a technology that does not conform to current military specifications (MIL-SPECS)?

Perceived high risk by the decision maker can easily stop a technology from being adopted even if the return is significant. Even though a PM and SPM attempt to increase the capability of their systems, they tend to avoid risk (36:32). Interviews with 76 laboratory, engineering, and system program office (SPO) personnel lead Cormier to conclude that since SPO's are rewarded on the basis of meeting defined cost and schedule requirements, they avoid risk (36:68,70). Hence, defined requirements may force the decision maker to substitute low-risk, high-return technologies for no-risk, low-payoff technologies. If the technology will increase risk and the requirement is not documented, it is doubtful the technology will be used.

LACK OF FUNDING

Without funds, the technology will not be inserted. It is not surprising that the Committee on Technology Transfer and Utilization listed funding as an essential step to technology transfusion (30:8). Lack of funding can stem from both lack of funds within a program and the inability to obtain an outside funding source. If the funds are within the program then all that is required is to convince the decision maker to allocate those funds for the technology. This allocation, however, must stand the competition of other requirements. PMs and SPMs must

continually trade off within their funding constraints. These trades may lead the decision maker to exclude a technology even though it has great potential. If the technology requirements have been documented, the decision maker perceives the risk to be low, and the benefits to be high, he will probably fund it. He can do this by allocating internal funds or seeking money from outside sources.

There are many external "pockets of money" that may be available for a high-return project; however, it can be a complex process to obtain funds from outside sources. AFLC recognized this and started an education process by publishing a pamphlet of over 20 funding sources their command can use (14:--). Identifying and applying for a funding source does not guarantee funding, but a low-risk, high-return project has a reasonable chance.

Technology candidates must compete for funds whether they are from internal or external sources. The outcome of that competition is in part determined by the next two impediments: the resistance to change and insufficient linkage/advocacy.

RESISTANT TO CHANGE

Another major obstacle to transfusion is resistance to change, especially between organizations (29:46). Mullis concludes from Congressional testimony, interviews with acquisition project officers, and personal experience that there are problems in moving technology across organizational boundaries (29:30-31,37). Furthermore, a 1986 survey of 79 laboratory, engineering, and systems program office (SPO) personnel cite the SPO resistance to change as the number one reason for unsuccessful transitions (36:47). Systems Command overcame many of their organizational obstacles for transitioning technologies by aligning the laboratories in the same organization as the SPOs they mainly support. Though this provided a great source of technology that did not have to cross major organizational barriers, it did nothing to break the barriers for outside sources of technology.

Additionally, Dr Lambright explains a resistance to change is wide spread and found it in each of the key federal agencies that make decisions on science and technology. He states that this is not all bad, but it too often slows transfusion, not for mission reasons, but for "self serving ends (5:4,6)."

This resistance to change can be overcome if organizations have sufficient linkages or there is an advocate to champion the technology. The next section will briefly discuss this issue.

INSUFFICIENT LINKAGE/ADVOCACY

Though there are many organizations and processes to transfuse technology, there is no organization providing needed continuity to the process. The insufficient linkage of the many organizations often amplifies the effects of the other impediments by either slowing or stopping transfusion. Mullis states that it is difficult to identify how the technology transfusion process is linked or where the responsibilities lie; however, he did state a "brokerage process" is necessary "to help match the needs to the technologies (29:38-39)." He concluded responsibility for technology transition is "ambiguous or nonexistent," and consequently slowed, when technology responsibility is passed from one agency to another (29:47-48).

An advocate can act as link to help the organizations needed to transfuse technology understand each other's "world." The three main groups (worlds) are the operational users, the technology developers, and the system acquirers. For example, a SPM is not very interested in acquiring a maintenance free battery for a system when his "world" tells him it will cost him money and any savings realized will go to the maintainer in the field and not his organization.

CHAPTER CONCLUSION

This chapter has looked at several of the major and closely related impediments to transfusing technology. First, undocumented requirements may force the decision maker to chose a no-risk, low-payoff technology over a low-risk, high-payoff one. Next, lack of information that a technology exists or not knowing what its benefits and risks are, was the most cited impediment to transfusion. The third impediment, lack of incentive/perceived high risk, stems from the personal and organizational motivations that are lacking to overcome the "business as usual attitude." The fourth impediment, lack of transfusion funding, is a solid barrier, even if the technology will save more money than it cost. Next, resistance to change, which is closely related to incentives and perceived high risks, blocks transfusion especially due to natural organizational boundaries. Finally, insufficient linkage/advocacy often amplifies the effects of all the other impediments. With these impediments in mind, the next chapter will briefly describe what one can use to help overcome these impediments.

Chapter 3

TRANSFUSION EXPEDITERS

Given the background of the problem from Chapter 1, and the impediments from Chapter 2, we will look at some the tools one can use to transfuse technology. These tools include organizations and processes structured in a sequence that approximates the way technology can be transfused.

STRUCTURE

PLAN	DOCUMENT REQUIREMENT	IDENTIFY TECH	VALIDATE	FUND	LINK/ ADVOCATE
PFII	SON/SORD	AFSC	SENTAR	JTIP (PRAM)	JLC
TTP	LN	USERS	ANALYSIS	(RAMTIP)	TAPM
P^3I	WSMP (PIWG)	OTHER SERVICES	JTIP	PREFERRED SPARES	AFCOLR
WSMP		INDUSTRY		VE	

Figure 1. Technology Transfusion Matrix.

AFCOLR	-	Air Force Coordinating Office for Logistics Research.
AFSC	-	Air Force Systems Command.
JLC	-	Joint Logistics Commanders.
JTIP	-	Joint Technology Insertion Program.
LN	-	Logistics Needs.
MAP	-	Mission Area Plans.
PFII	-	Project Forecast II.
PIWG	-	Product Improvement Working Group.
P^3I	-	Preplanned Product Improvement.
PRAM	-	Productivity Reliability Availability and Maintainability.
RAMTIP	-	Reliability and Maintainability Insertion Program.
SENTAR	-	Senior Engineering Technology Assessment Review.
SON	-	Statement of Operational Need.
SORD	-	System Operational Requirement.
TAPM	-	Technology Application Program Managers.
TTP	-	Technology Transition Plans.
VE	-	Value Engineering.
WSMP	-	Weapon System Master Plan.

Table 1. Figure 1 Abbreviations.

There are many avenues technology transfusion can follow. This paper will use the following sequence which approximates the sequence determined by the HQ USAF/LE R&D for Logistics Tiger Team (33:--): plan, document requirements, identify technology, reduce risk through validation, fund, and link/advocate insertion. The organizations/processes often extend beyond any one of these categories, however, they have been arranged under particular categories for clarity.

Plan

One of the best ways to facilitate the transfusion of technology is to plan for it. Planning can take place from both a technology and a systems perspective. This chapter will discuss five planning tools from the above perspectives: Project Forecast II, preplanned product improvement, technology transition plans, and weapon system master plans, and product improvement working groups.

Technology Perspective. Planning for the transition of a technology includes the very long range Project Forecast II and the short term technology transition plans.

Project Forecast II. - Project Forecast II was a one time study directed by Secretary of the Air Force and the Chief of Staff of the Air Force and conducted under the auspices of Systems Command Commander to look at revolutionary technologies 10 to 20 years in the future and build a "practical but hard-charging roadmap (54:1)." This study, completed in early 1986, identified 39 technologies and 31 system's initiatives that are high-return (54:2) and high-risk technologies. These technologies should be considered for the future, but are probably too high risk for transfusing today.

Technology Transition Plan (TTP). - TTPs are optional annexes to Advanced Technology Development Plans (ATDP) which set the criteria and strategy on what, when, and how a technology will be transitioned (15:1). These laboratory developed plans, roadmap the transition of technology to one or more users, and then establish written agreements between the laboratories, the engineering community, and the users. As of December 1987, 89 plans had been signed (61:--).

POC: ASD/ENST, Mr. Ted Stein
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System Perspective. This section will look at two planning tools that can be used, outside the Systems Command normal acquisition process, to provide an opportunity for a technology to become a programmed part of a system's natural evolution. Two major instruments of this planning area are Preplanned Product Improvement and Weapon System Master Plan.

Preplanned Product Improvement (P^3I). - P^3I is a technique to plan for the modernization of developing systems today, so a needed or desired technology can be inserted in the future with minimal efforts. P^3I can greatly enhance the transfusion of technology through various techniques including modular designs which are facilitated by such things as standard connectors. This, in turn, will make it easier to take advantage of form, fit, and function replacements as required by some modifications such as preferred spares (see FUND section). With the flexible designs that P^3I develops, future decision makers will opt for more incremental improvements that technology can deliver, thus extending the useful life of our systems. Below is a Defense Systems Management College chart (52:--) showing where P^3I can be used in the acquisition cycle.

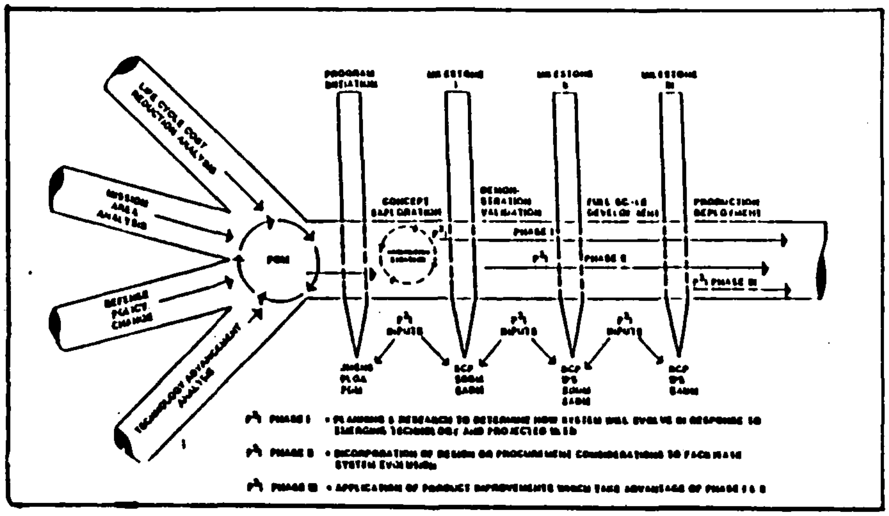

Figure 2. System Acquisition P^3I Cycle (52:--)

Weapon System Master Plan (WSMP). - The WSMP is a 10 year projection of operational and logistics requirements for a weapon system. It provides a "big picture" look the System Program Manager (SPM) uses to manage his weapon system. One of the sections titled "Technology Insertion Opportunities," is designed to describe "needed capabilities/unresolved deficiencies for which there are no fix programs due to lack of available technology (51:2,13)." These deficiencies are often discussed and documented during a PIWG, as discussed in the next section. Since the WSMP is used as a programming document by the SPM, a technology included in the document will be considered as a requirement. This documentation will not assure the technology is inserted, but it will make it part of the new baseline and therefore, greatly enhances its chances. As of December 1987

there were 14 WSMP, with 17 expected to be complete by April 1988 (62:--).

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Product Improvement Working Group (PIWG). - The PIWG is part of the Product Improvement Program to provide feedback to the person with overall program management responsibility (PMR) for "large, complex products with many deficiencies (21:2)." The PMR will be in Systems Command prior to program management responsibility transfer (PMRT) and in AFLC after. The PIWG can provide a forum to discuss the weapon system and what its priorities should be, however, by regulation it should not address supportability and safety issues (21:2). To keep these issues in perspective, the operating commands are increasing their role in collecting and prioritizing problems and coordinating agendas (27:--). The PIWG provides a link with the user and the supporter of existing systems that can be used to insert technology.

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Document Requirements

The users set the requirements that "pulls" the technology into systems. Requirement can be set using Statement of Operational Needs/System Operational Requirements Documents (SONs/SORDs), Logistics Needs (LNs), and Weapon System Master Plans (WSMPs). Since WSMPs were previously covered, they will not be repeated here.

Statement of Operational Need/System Operational Requirement Document (SON/SORD). - SONs are operational requirements formally documented by the operator. The SON has three main uses: "It defines an operational need, obtains official validation of the need, and furnishes preliminary guidance for planning by the responsible and implementing commands (20:2)." If the SON's Program Decision Package successfully competes for funds, a program is initiated. SORDs then provide updates to the SONs at subsequent milestones. The SORDs can more thoroughly describe the need than the SON as they are not limited to five pages. Additionally, requirements specified in the SORD can help drive the system as the SORD is written the same time as the system specification (49:--; 53:98-99).

POC: HQ USAF/XOXFQ; Mr Dan King
AV 225-7107; Commercial: 202-695-7107

Logistic Need (LN). - LNs form a less formal and cumbersome needs requirements process that documents, prioritizes, and seeks

solutions for select high priority support/maintenance technology needs. These needs are validated and prioritized by the MAJCOMs at an annual meeting. The list of needs is then sent through the Air Staff to Systems Command for action. In this process, prioritized needs are given visibility by publishing over 4000 copies of the needs to DOD, Air Force, and industry. Additionally, there are a small number of LN managers that actively seek solutions to select LNs (41:--).

POC: AFCOLR/ME; Lt Col Kenneth Dollar
AV 785-4758; Commercial: 513-255-4758

Identify Technology.

This section contains organizations that can identify high-return, low-risk technology candidates. As mentioned in Chapter 1 there are billions of dollars in technology ready to enhance our combat capability, the question is how to gain visibility and access to this technology. We will briefly look at four sources: Air Force Systems Command, users, other Services, and Industry.

Air Force Systems Command (AFSC). - AFSC is the key organization in transfusing technology on our developing systems. AFSC gathers information on technologies both inside and outside their organization. Inside their organization they have five product divisions and 14 laboratories that can identify technology. The Program Managers (PMs) in the product divisions make the decisions to accept or reject technology on developing systems and hence, are targets of any effort to transfuse technology. Because of their decision making role, PMs are exposed to and evaluate many technologies which they can share. The development planning (XRs) and the engineering (EN) directorates in the product division often take on the role of sharing the technology that PMs are exposed to.

A notable example of AFSC working outside their organization was TECHINSERT (16:1). This one time effort in 1986 developed a list of high-return R&M related technologies that were ready for insertion. At the direction of the Systems Command Commander, industry was widely solicited for the technology candidates. The results were validated and prioritized by a panel of experts before being released for program managers to use.

Users. - Users of technology can provide a good information source for technology because they have the practical experience to know what is good and what is bad. Users in one MAJCOM often do not pass the word to other MAJCOMs about what technology will leverage their efforts because of work load of each of the MAJCOM staffs. Though the individuals in the MAJCOMs are more than willing to share their knowledge, due to other primary duties they are often put in the position of having to trade off

accomplishing their chartered duties for helping other Air Force organizations.

<u>Other Services</u>. - The Army, Navy, and Marines, all have their own sources of technology that can benefit the Air Force. Like the users, they can provide technologies they have validated on their systems. Ways to identify these technologies include joint forums, such as the Joint Logistics Commanders, that can provide information for inter-service transfusion. The JLC will be covered in more detail in this chapter under <u>Link/Advocate</u>.

<u>Industry</u>. - Industry does about seventy percent of the research and development (R&D) (7:82). They perform not only most of the government laboratory efforts which are contracted out but also their own R&D to remain competitive.

Two of the ways one can find out about industry's technologies include: Independent Research and Development (IR&D) and individual contractors. One of the categories of industry's R&D that the government can take advantage of is Independent Research and Development (IR&D). Though IR&D is independent of a government contract, the government can influence it and take advantage of it. They can influence it by evaluating the R&D and providing feedback to the contractor. One can take advantage of the IR&D process by becoming an evaluator and learning what technology can deliver, which in turn will help him write better specifications.

POC: HQ AFSC/XTXC; Dr Fran Rensvold
AV 858-4736; Commercial: 301-981-4736

Individual contractors is another source and is how most of the transfusion is done (36:34). The contractor who possesses the technology is motivated by profit to "sell" his technology. On the other hand, the contractor that is developing a system will be resistant to adding a technology that will replace one he is making a profit on.

<u>Reduce Risk/Validate</u>

If the perception of risk can be reduced the technology will stand a much greater chance of being accepted. This section will describe how the perception of risk can be reduced by validating technologies in general (analysis), before the first application (SENTAR), and both before and after the first application (JTIP).

<u>Analysis</u>. - Analysis for low-risk technology should be kept to a minimum as the technology has already been proven on a system or prototype. The analysis, however, can be used to look at the differences between the current and future application. The sources of analysis are many including MAJCOMs, laboratories, SPOs, and industry.

Senior Engineering Technology Assessment Review (SENTAR). - SENTAR is an Aeronautical Systems Division (ASD) unique organization that validates Air Force Wright Aeronautical Laboratory (AFWAL) technologies for use in ASD systems. Their validation process can be broken into two major steps. First, they review the laboratories' technology transition plans (TTPs) from an engineering perspective and make recommendations. They also sign the TTPs along with the laboratory and the perspective user. Second, SENTAR assesses the technologies as they mature. Using a disciplined engineering approach, they review technologies for 9 transition criteria (61:--). Those that pass the test receive the SENTAR "stamp of approval," which signals the program managers in the SPOs the technology is ready.

POC: Mr Ted Stein, Jr., ASD/ENST
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Joint Technology Insertion Program (JTIP). - JTIP provides a mechanism to prototype a technology or insert it for an initial application, thereby, validating the technology. Additionally, prototyping actually reduces the risk and not just the perception of risk. Key to these efforts is the ability to quickly fund projects; hence, JTIP will be covered in more detail in the next section.

Fund

There are many sources for funding technology transfusion. This section contains a few that the reader may be able to use. In particular it will cover JTIP, Preferred Spares, and VE.

Joint Technology Insertion Program (JTIP). - This program reduces risk of inserting technology. It is a joint AFSC/AFLC organization controlled by a general officers steering group representing a cross section of the Air Force. The organization is broken into two divisions: Productivity, Reliability, Availability, and Maintainability (PRAM) and Reliability and Maintainability Technology Insertion Program (RAMTIP).

PRAM - The objective of PRAM is to reduce operational and support (O&S) cost and improve the combat supportability of fielded systems. PRAM does this by providing funds to prove a technology through prototyping and testing, thus reducing the risk of inserting a technology (18:--; 19:--).

POC: ASD/AEM, AFALC/RA; Lt Col Silliman
AV 785-6201; Commercial: 513-255-6201

RAMTIP - The objective of RAMTIP is to develop and accelerate the transition of new, high leverage technologies into fielded and future systems. These technologies should be mature enough to require no more than a full scale

development effort to validate their military potential and application (17:--).

POC: AFALC/RAR, ASD/AEMR; Lt Col Heming
AV 785-8335; Commercial: 513-255-8335

Preferred Spares. - Preferred spares is one of the most effective ways to transfuse technology. It substitutes an improved spare (possibly containing a new technology) for an old one during routine maintenance and depot repair cycles. This is done using form, fit, and function replacements. Preferred spares may be used before the failure of the old part and may allow minor fit changes if the "new part provides significant cost or R&M benefits (32:--; 42:272)."

POC: HQ USAF/LEYYS; Mr Harry Brown
AV 227-1177; Commercial: 202-697-1177

Value Engineering (VE). - Value Engineering can provide a source of money for improvements in baselined systems, equipment, facilities, services, and suppliers to achieve essential functions at the lowest life-cycle cost (LCC) while still maintaining the required performance, reliability, maintainability, interchangeability, quality, and safety (34:--; 35:--; 23:--). This source can be used for insertion if the technology can reduce overall projected cost to the Air Force and still maintain the essential system functions; however, federal acquisition regulations and MIL-STD-480 must still be complied with.

This program provides monetary incentives for both the contractor and the government. Government employees are eligible for various monetary and recognition awards while the contractors can legally double their authorized profit levels. After the cost of the implementation is recovered, the remaining savings are shared between the contractor and the government. The contractor can earn up to 50 percent of the acquisition savings (35:--).

POC: ASD/ENSI, WPAFB; Mr Grover Cleveland
AV 785-3460, Commercial: 513-255-3460

Link/Advocate

These organizations' main purpose is to bring other organizations together, increasing the connectivity and efficiency in the technology transfusion process. The JLC, TAPMs, and AFCOLR will be discussed.

Joint Logistics Commanders (JLC). - This group was formed to provide inter-service cooperation and coordination. Its principal members include three four-star generals from AFLC, AFSC, and the Army, and one vice admiral from the Navy. They direct a number

of panels and groups that have significant potential to transfuse technologies between the services. The Joint Policy Coordinating Group for Logistics Research, Development, Test, and Evaluation (Log RDT&E) and the Depot Modernization Initiative, Joint Technology Exchange Group (JTEG), both have multi-service, multi-agency representation with the charter to transition technology. The Log RDT&E charter states their goal is to explore "common efforts, identifying voids or shortfalls, and developing candidate programs of a generic nature for JLC endorsement to OSD (50:2)." The JTEG charter calls for a "joint group to improve technology, new processes, or new equipment into aeronautical depot maintenance activities (37:3)."

Log RDT&E POC: HQ AFSC/FLLX; Col Eugene Tattini
AV 858-2174; Commercial: 301-981-2174

JTEG POC: AFLC LOC/AT; Mr Jerry Schmitt
AV 787-4055; Commercial: 513-257-4055

Technology Application Program Manager (TAPM) Program. - The objective of this program is to accelerate the transfusion of technology into the Air Logistics Centers (ALCs) and thereby into weapon systems. They have built a network of individuals that includes people at each ALC along with representatives in 17 technology areas. Their job includes identifying technology candidates, sponsoring those technologies into a particular ALC, and then transfusing them into other ALCs. Working hand in hand with the SPM, the TAPMs facilitate two to four prototypes or actual insertions for each technology candidate (56:--; 58:--).

POC: Mr Kenneth Purvis, HQ AFLC/MMTEC
AV 787-3435; Commercial: 513-257-3435

Air Force Coordinating Office for Logistics Research (AFCOLR). - This office is specifically "charged to encourage pursuit of combat support R&D with emphasis on technology insertion in current and future weapon systems (11:1)." AFCOLR has four mission elements (11:4):

1. Coordinate/administer Logistics R&D requirements activities.
2. Facilitate the transfusion/transition of technology and information.
3. Manage the Air Force logistics participation in the DOD IR&D program.
4. Enhance Air Force awareness of operational support R&D efforts.

They have carried out this mission by running several programs including LNs, the logistics input into the IR&D process, the Air Force/Industry Senior Level Visit (SLV) program, the Blue Two Visit (BTV) program, and a newly formed technology

transfusion division. Since LNs were explained under Document Requirements section and IR&D under Identify Technology, they will not be repeated here. The SLV program brings senior Air Force and DOD officers to visit top corporate leaders to discuss issues that affect operations. The BTV program brings senior government and industry design engineers and program managers to operational locations where the two stripe airman (blue two) show them just what the operational needs are. The details of the technology transfusion division are not yet complete, but the functions being considered are (48:3):

1. Identify, validate, and document suitable technologies.
2. Conduct a wide-spread information program advocating selected technologies.
3. Identify and analyze barriers to technology insertion and facilitate removal.
4. Conduct special technology transfusion projects.

POC: AFCOLR/TT; Lt Col Larry Ingalls
AV 785-1606; Commercial: 513-255-1606

CHAPTER CONCLUSION

There are many segments of a technology transfusion process that are doing a great job at what they are chartered to do. If these organizations could be linked into a unified effort to transfuse technology there are few barriers that could not be overcome. The next chapter will analyze how these organizations and processes presented in this chapter can be used to overcome the barriers presented in Chapter 2.

Chapter 4

ANALYSIS AND RECOMMENDATIONS

This chapter will make recommendations based on an analysis of how the expediters from Chapter 3 may be used to overcome some of the impediments described in Chapter 2. Specifically it will analyze and make recommendations in the following areas: planning, documented requirement, information, reduced risk, funding, reduced resistance to change, and linkage/advocacy.

PLANNING

The planning area of technology transfusion can present many opportunities to insert high-payoff low-risk technologies on many systems in a systematic way. Dr. O'Keefe chose "user centered planning" as the most important element in transfusing technology (9:83,85). This section will examine TTPs, P^3I, and WSMPs.

The technology transition plan provides a useful model to develop technology transfusion plans which could be developed to fill the void in planning for technology beyond the first application. Transfusion plans could roadmap a high-return low-risk technology to transfuse it across the Air Force (and DOD). Identification of impediments, means to overcome them, and signatures by the those acquiring, using, and funding the technologies should all be essential parts of the plan. The time sequence of events coupled with the commitment of the key players should allow some transfusion steps to be run concurrent thus accelerating the process.

P^3I is a technique that should be used on many systems. Even if a technology on a system is considered high return by today's standards, it probably will not be in 40 years when that system is still in our inventory. P^3I can make it faster and cheaper to insert a technology. It could have been used on the F - 16 C/D for the Advanced Medium Range Air to Air Missile (AMRAAM) by building the appropriate wiring harnesses in the airframe. Even though this was not done, the AMRAAM was inserted because the need was sufficient to overcome the barrier of the tens of millions of dollars it took to retrofit the fleet. P^3I could have significantly reduced this cost barrier by designing the internal wiring in up-front (34:--).

WSMP provides a means to document requirements that the SPM will use to manage his system. They have the potential to be the central planning document for fielded systems since documented technology requirement become part of the program baseline. Once part of the baseline there will be inertia to insert the technology. PIWGs are good forums to discuss and agree on the content of the plan. Since the contents of the plan is highly dependent of the AFLC PMR, the continuity of the plan and system could be improved if the PMR would transfer from Systems Command to Logistics Command when the primary management responsibility transfer (PMRT) for the program occurred.

Section Conclusion

The planning processes are important to transfusing technology. We should use the planning mechanisms that already exist like P I and WSMP, but not limit ourselves to just them. A technology transfusion plan should be developed along the lines of the technology transition plans. These plans should include or call for documented requirements, as will be covered in the next section.

DOCUMENTED REQUIREMENTS

Documented requirements form the framework for transfusion. The Packard Commission Report points out we need to do "a better job of determining requirements (31:xxiii)." These requirements should be documented in the program management directives (PMDs) statements of work (SOW) to drive the acquisition process. SONs/SORDs, LNs, and WSMPs are some means to do this.

Documented requirements in the PMD and SOW are instrumental in transfusing technology. The PMD direction to the SPO and the SOW direction to the contractors (and ALCs) provide the baseline for competition. The requirements in general should be documented in performance terms, thereby, allowing the government and industry decision makers the latitude to make the best tradeoffs for the system; however, if we know a technology should be used, we should specify the contractor use it or justify why not. A case in point is carbon-carbon brakes. These brakes were proved in 1971 on the F-15. Relative to beryllium brakes, they are lighter, cost less, and stronger; yet, in the F-16 C/D, beryllium brakes were initially used. Shortly thereafter, the brakes were replaced with the carbon brakes through Value Engineering (34:--). The additional expense of changing these brakes was unnecessary, and certainly a impediment to transfusing the better and cheaper carbon brakes. All in all, requirements should be documented, normally in performance terms but, on occasion the technology should be specified.

On the path to writing the requirement in the PMD and the SOW one can use SONs/SORDs, LNs,and WSMP. The SON/SORD takes the longest but it almost always results in the requirement being documented in a PMD, and consequently, in a SOW if the PMD is funded. The LNs are validated and prioritized Air Force requirements that are distributed to both the government and industry. High priority LNs are now being documented in PMDs, thus providing greater usefulness for LNs. SONs/SORDs, LNs, and WSMP all provide the users view which is essential to a good PMD or SOW.

Section Conclusion

The technology requirement should be documented so it can find its way into the PMDs and SOWs. SONs/SORDs, LNs, and WSMPs are useful means to accomplish this especially considering their user orientation.

INFORMATION

Increasing information about a technology, its benefits, risks, and cost can be one of the best ways to accelerate transfusion. Gathering information is complicated by the many sources which include: AFSC, users, other services, and industry.

Systems Command developed a list of "opportunities for accelerated insertion of advanced technology" in their one time effort, TECHINSERT (16:1). It would be useful if this list of "advanced technologies" were be kept current and one created and maintained for mature technologies, it could be called a "TECHFUSION" list.

Users both in the USAF and in other services can be one of the best sources of information. The high-return technologies they have to offer have been proven in operations and, as such, pose little risk. Furthermore, a user can identify technologies that can be used in operations better than a technologist because he works with it daily, and knows how it performs under actual conditions verses a sterile laboratory environment. Though operators are in one of the best positions to transfuse technology they often do not have the incentive or the charter to do so.

Other services can provide a wealth of technologies useful to the Air Force. Gaining visibility to those technologies will have to be a participative effort with incentives built in. The JLC has the framework to build on; unfortunately, there are some limitations that will be discussed under linkage/advocacy section.

Industry is and will continue to be one of the prime sources of technology and as such should be incentivized. Contractors will respond to what they perceive will benefit them and will fill the users-needs. Contractual incentives (or at least not disincentives) should encourage industry to search for and market technologies that provide significant benefits to the user. Since industry's marketing approach is often viewed with skepticism because of their driving need for profit, some unbiased organization should act as an "honest broker" to help build confidence the technology that is advertised as high-payoff low-risk, really is.

<u>Section Conclusion</u>

There are many sources of technology available. A means to quickly find and validate these technologies does not exist. A program similar to TECHINSERT should be developed to identify the most promising high-return, low-risk technologies. The source of this "TECHFUSION" list should be sought through Air Force users, AFSC, other services, and industry. For this list to be a credible list it will have to first be validated and prioritized, thereby, reducing risk to one who might use it.

INCENTIVES/RISK

Since lack of incentives or perceived high risk can stop transfusion, one should attempt to increase positive incentives, decrease negative incentives, and reduce risk. Increasing positive incentives for industry can be done by improving a company's reputation (hence increasing the chance for future market share), reducing risk, and improving the short-term profit (28:96-97). Similarly, negative incentives should be reduced, especially via the contract and MIL-SPECs. Once universal technology application has been shown, the MIL-SPECs should be changed. In the meantime waivers should be granted easily, possibly they should even be blanket.

Perceived high risk can stop a transfusion regardless of how low the actual risk really is. Analysis can bring these perceptions closer to reality by projecting some of the problems that might be encountered on new applications as well as the benefits. The key to the analysis is finding the expert with the information needed rather than going from time consuming and expensive study to study. Since technologies and systems are so diverse, the analysis could be performed by a modular panel of experts, the composition depending on the application being considered.

The panel should include participants from the operational and technical areas with emphasis on the user. One of the most reliable sources of information on technology risk, is a user's

report of technology performance in operations. If the user endorses the technology, it should be considered for Air Force wide application; however, more is needed. The technical experts should provide the engineering knowledge to assess, acquire, and insert the technology while the operational experts provide the requirement and "sanity check" to better understand how the technology will work under operational conditions. Technical people may come from such areas as engineering, SPOs, and laboratories, while operational experts should come from the operators, maintainers, and logisticians. Information to validate the technology may come from sources like SENTAR or could already be documented in MAJCOM reports. If one still considered there was too much risk, then the panel could be used to prototype the system through such means as JTIP. Regardless of how much "proof" there is that the technology is low risk, it may not be understood by the decision maker without an unbiased advocate.

Section Conclusion

Contractual incentives that have the potential to increase profit are one of the most effective ways to incentivize industry. Though MIL-SPECs serve an essential purpose in maintaining standards, they can become outdated as technology progresses. If this occurs the MIL-SPECs should be changed with waivers routinely granted in the meantime. In addition to incentives being improved risk should be reduced. A modular panel of operational and technical experts could quickly evaluate a low-risk high-return technology. Their endorsement should make that technology a candidate for Air Force wide application.

FUNDING

There are many sources of funding that can be used to transfuse technology, including internal funds, preferred spares, and value engineering (VE). Though there are many sources there is still a shortage of funds, in part because transfusion is considered by many to be a cost and not an investment.

Technology transfusion is an investment not a cost (9:83,88) is an idea that should be understood by those dealing with low-risk high-payoff technologies. JTIP has shown that it can average over a 5:1 short term return on investment and over a 25:1 life cycle return (59:--). Even with returns like these JTIP has been subject to the budget cutting process, leaving many unfunded high-return technologies. On programs with returns like these we could avoid much of the short term financial mindset could be avoided if the funds were self generating. The account could be managed using a revolving fund or a contractor that would use the "profits" (savings) from past technology projects to "invest" in new ones. The savings could be divided between the revolving fund, the command to receive the new technology, and

the finder of the technology. This would not only provide funds for transitions but also incentives for the participants.

Preferred spares is another method of inserting a technology by using funds designated for a less capable spare. A great advantage of preferred spares is the speed they can be implemented. Since funds and usually manpower are programmed to install spares, all that is needed is a form, fit, and function technology to complete an insertion. An education program on how to take advantage of this source would be useful.

Value engineering funds are available whenever funding can be generated from cost savings on an existing contracts. VE's benefit sharing makes participation a win-win situation for industry and the government. Like preferred spares, lack of education of the uses and benefits of VE appears to be its biggest shortfall.

<u>Section Conclusion</u>

There are many sources of funds available, such as, JTIP, preferred spares, and VE; however, they are limited. The money it takes to transfuse technology could be generated from savings realized. A revolving account could be used to transfuse technology and incentivize the participants.

REDUCED RESISTANCE TO CHANGE

Overcoming resistance to change can be done both internal and external to an organization. Internally, management can help set an atmosphere that is receptive to change. As General Randolph cautioned this should not be an unconstrained, unrealistic receptivity for change but a receptive engineering disciplined approach (57:--). Commitment by the top management in the buying organizations (e.g. SPOs and ALCs) is the first step in setting the tone for transfusion.

Externally, three significant changes could be made. Since most resistance to change occurs between organizations, and AFLC and AFSC are the two organizations that have program management responsibility for a system, merging the two organizations would eliminate many barriers. There of course would be many other considerations to such a change that are beyond the scope of this paper. The second possible change is less radical than the first and involves matrixing. Technology source organizations could collocate people in the technology need organizations and/or vice versa. As these people are accepted as part of the other organizations, the resistance to change due to organizational barriers will be reduced. This has been demonstrated by the Air Force Acquisition Logistics Center (AFALC) and Aeronautical Systems Division (ASD) in their interfaces within the SPOs and

the laboratories. AFALC matrixes logistics personnel into the SPOs in a mutually beneficial arrangement. The logisticians work in the SPO helping the program manager and at the same time provide a voice for logistics considerations. Similarly, through the Integrated Logistics Technology Office (ILTO), logisticians work in the ASD laboratories side by side the technologist. Short of combining AFLC and AFSC, matrixing appears to be one of the best ways to reduce the organizational barriers. The third change to enhance transfusion is to increase "advocacy." Gee deduces the primary barrier to transition is lack of "marketing" (4:15). This will be covered in more detail in the next section.

Section Conclusion

In summary, resistance to change can be overcome internally and externally. Internally, management can set a receptive atmosphere for technology transfusion. Externally, both AFSC and AFLC can reduce many of their barriers by using advocates and matrixed organizations. An external advocate teamed with an internal "top management" advocate make an effective team.

LINKAGE/ADVOCATE

There are many mechanisms that can be used to transfuse technology, but unless there is an advocate who understands and can link them, the process will be haphazard. There are many innovative technologies available in the government and industry, but there is neither a unified program to transfuse them across multiple systems nor an organization that has oversight for the transfusion programs available. Such an organization should exist to act as a "technology clearing house" that advocates the linking of the required organizations/processes needed to transfuse high-payoff technologies.

One of the best ways to link the organizations and help overcome the above mentioned barriers is through an advocate. An advocate can help provide the linkage needed to document the requirement and to find, validate, and fund the technology, not just for one system but for many.

This section will cover several attributes the advocate organization should have to link the dissimilar worlds in the using, developing, and acquisition communities. First, it should have a "big picture" marketing approach that should be understood and accepted by the participants as beneficial. Next, it should network key people into the transfusion team to make them part of the transfusion process and increase their commitment. Finally, the transfusion organization should be modular to allow for efficient operation and evolutionary implementation of a system that can provide a systematic way to transfuse technology across the Air Force.

Big Picture

This advocate should obtain a "big picture" look at how to link the required processes to transfuse technology. Full time advocates would be able to step back from the many details to get the big picture required to manage such a diverse project. Even though this will dilute the depth of knowledge of the individuals it can still be effective, as research has shown that detailed knowledge is not required to advocate a technology. Brink states that individuals with only a "passing knowledge" of a subject can serve as a link between other individuals (26:25-27); however, technology acceptance depends on the perceived need for the technology, the credibility of the source, and the criteria (26: 74). Hence, each of these should be considered in the marketing approach.

Marketing Approach

Though there will be some credibility problems with a marketing approach, it is essential as study after study has shown (2:--; 3:--; 4:--; 5:--; 9:--). It was already mentioned that Gee found lack of a marketing approach to be the number one barrier to transfusion (4:15). Lambright also said the marketing approach is essential to transfusion (5:167). Furthermore, Doctors found in studying NASA's Technology Utilization Program (TUP) that literature was semi-effective in transfusing technology but interpersonal contact on a continuing basis is required to transfuse effectively (2:167). Little's analysis of NASA's TUP yielded similar conclusions saying an "entrepreneurial approach" is much more effective for the cost than simply publishing information (3:106-108). Furthermore, O'Keefe agrees a "marketing" approach is required but cautions the research community frowns on sales techniques as being unprofessional (9: 86). Consequently, there must be an advocate who can market the technology in a personal yet unbiased way to the decision maker.

Networked Approach

If the skeptics help form and guide the advocate, they will consider him more credible (and he will be). Allen's 10 year study of technology found decision makers mostly rely on the expertise of a few "technology gatekeepers" that had shown to be helpful in the past (1:141-145). He goes on to say that an indirect approach to pass information through these gatekeepers is more effective than going directly to each of the decision makers (1:149). Consequently, an unbiased advocate organization using a networked approach could effectively improve technology transfusion.

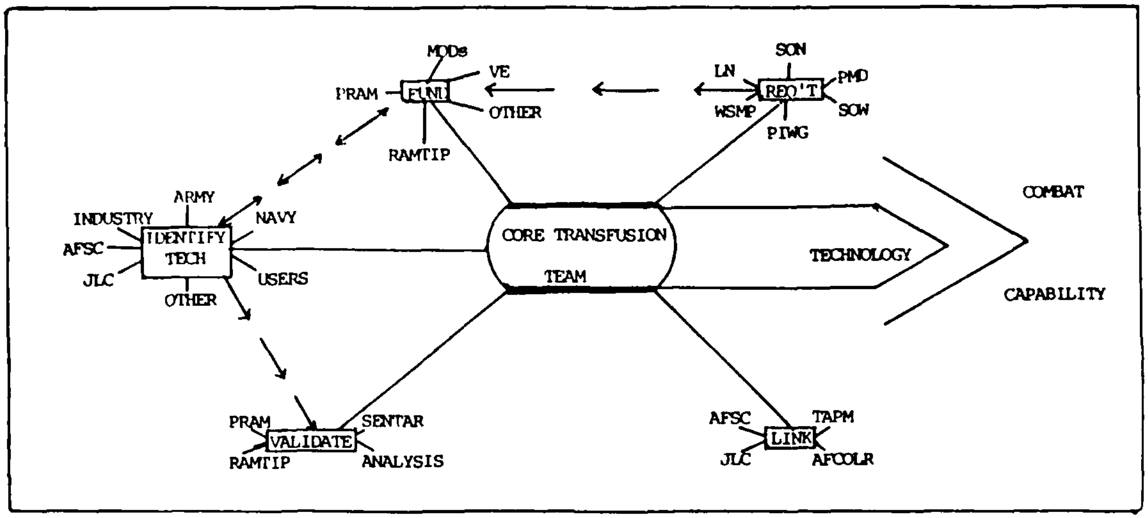

Figure 3. Technology Transfusion Network.

The structure would include a core team that could integrate efforts and work generic problems, while the networked experts provide help and guidance in obtaining mutually beneficial goals. The core team should consist of a mix of disciplines that can interface with the key players in the transfusion process to include those that operate, maintain, acquire, support, fund, and analyze systems. After the disciplines are chosen, individuals in key organization could then be selected and trained. Since these technology gatekeepers (in each organization) were chosen because of their current position and expertise, there should be little change in their current duties. They would, however, have some change in duties to include passing information to the core team (maybe via computer) as well as accepting guidance from them.

In general, the core team guidance provided will be followed if its congruent with organizational and personal goals. Goals will tend to be more congruent if top management supports the transfusion effort, their charters reflect it, and positive incentives are offered. The National Academy of Engineering found top management seldom supported transfusion efforts if their organization was not chartered to do so, and employees seldom worked the transfusion issues without management support and tangible rewards (30:24). Consequently, charters should reflect the organizations expanded role in transfusion along with their leaders providing top down support. A general officers steering group consisting of the major organizations should further solidify support as it did for JTIP (59:--). Making organizations part of the process by networking and including positive incentives should further ensure the process considers and fulfills organizational and personal goals.

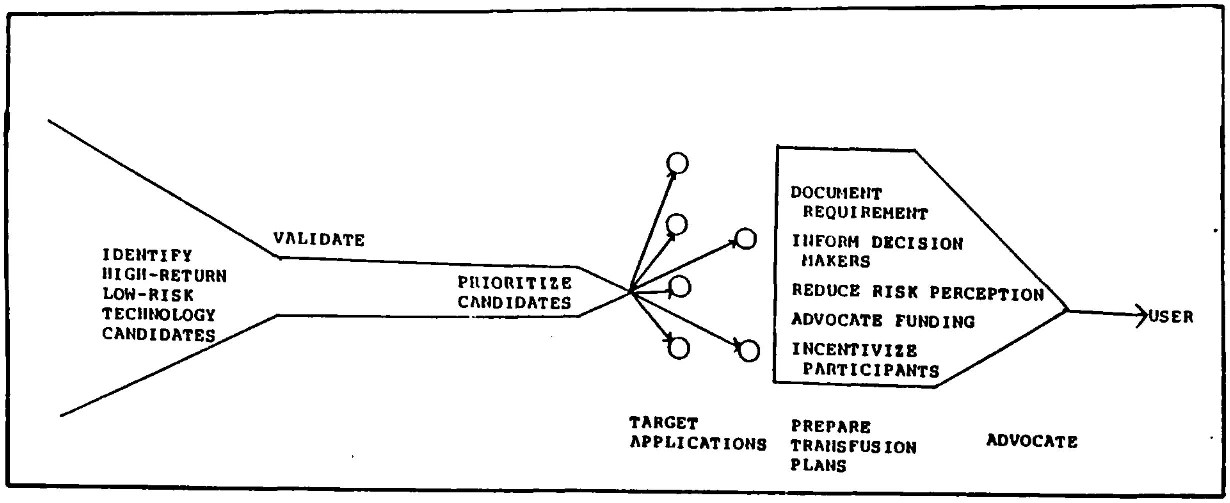

Figure 4. Technology Transfusion Process.

This networked approach should help provide a systematic way to: identify high-return low-risk technologies, validate them, prioritize those with the greatest return for the Air Force with acceptable risk, target current and developing systems across the Air Force, prepare technology transfusion plans, and then advocate select technology insertions.

<u>Modular</u>

The advocate network should be modular in its structure as well as its implementation. The modular structure would be efficient in that the members of the transfusion team would not become active unless needed. This is dependent on a core team knowledgeable enough to know who to involve and who not to. Additionally, a modular implementation can provide an evolutionary change, starting with a small core team and only a few select organizations that can be effectively coordinated. Initial activities could include linking key players and gathering and distributing information to help plan, link, and advocate transfusion. The next increment may be to develop select transfusion plans followed closely by advocacy. The real synergy of the plan would be from full implementation.

A transfusion team with the above attributes should obtain a "big picture" look at how to market technologies across the Air Force, using a networked approach that can be implemented in a modular fashion. The next question one may ask is who could function as the core of this transfusion team?

Candidates

Of the organizations listed under "Link/Advocate" in the previous chapter none fully met the desired criteria. The JLC structure has tremendous potential, but it has only a few full time members, little money of its own, and services not very enthusiastic about committing their money to "purple" projects they lose control of. The TAPM program, though relatively new, is doing a good job of advocating technologies into and across the ALCs, which in turn will benefit our systems. The TAPMs, however, may be considered biased as they are part of AFLC and as such may be viewed as having parochial interest. This AFLC bias is especially suited to the job of transitioning technology into the ALCs but less appropriate in presenting an unbiased Air Force view. AFCOLR is the last organization listed and the author's choice as the main logistics technology advocate and integrating organization.

AFCOLR has more positive attributes for this job than drawbacks. The main advantages to AFCOLR, include its reputation as an "honest broker," the experience it has gained in coordinating activities to help transfuse technology, and its reporting chain. Their reputation as an "honest broker" stems mainly from the way they have handled past coordinating jobs. Though they have not fully taken on the role of advocating and integrating technology transfusion activities, they have had some limited experience. This experience has given them many contacts in each of the operational commands, AFSC, and AFLC. The reporting chain is another advantage to AFCOLR as it provides top level neutrality on what have traditionally been considered competing interest: logistics and traditional performance. Their reporting chain goes through a general officer (AF/LE-RD) who reports directly to top levels in both the logistics side (AF/LE) and the research, development, and acquisition side (SAF/AQ). The guidance from the SAF/AQ is essential to keep the research and acquisition priorities compatible. Though AFCOLR is aligned better than any other organization examined, it could be improved by bringing in a more direct user influence, either through a strong link to the top leadership in the MAJCOMs and/or the operations side of the Air Staff (AF/XO). This last action would also go a long way in increasing its clout, which is one of the two major drawbacks.

The main drawbacks for the job are insufficient manpower and clout. The manpower problems could be overcome by augmenting their in house manpower, contracting out parts of the task, and/or implementing less than a full transfusion team. The clout problems could be overcome by incentives for the participating organizations and individuals. Additionally, regulations, such as, AFR 80-1, and organizational charters could be changed to reflect the new and inter-related roles of the transfusion organizations. Currently, AFR 80-1 only addresses advanced

technology (15:1) and the corresponding organizational responsibilities (15:2-3).

Section Conclusion

There are many organizations that help transfuse technology but unless there is an advocate to help link those organizations, the process will continue to be haphazard. The advocate should have several attributes to include a "big picture" perspective and a marketing approach. The advocate would not be an individual, but rather a core group of experts that could pull together a large network of key players that operate, maintain, acquire, support, fund, and analyze systems. Each participating organization would have to be incentivized to participate by such things as top management support, personal recognition, and regulations and charter changes. This network could be organized in an evolutionary and efficient way by using a modular approach. Of the existing organizations, AFCOLR appears to be the best candidate to develop the core team from.

CHAPTER CONCLUSION

This chapter has analyzed the impediments to technology transition in relation to some potential solutions. Specifically it has analyzed and made recommendations in the following areas: planning, documented requirements, information, risk, funding, resistance to change, and linkage/advocacy. Based on this analysis and the recommendations, the next chapter will present a conclusion and summarize the recommendations.

Chapter 5

CONCLUSION

This report concludes the transfusion of high-payoff low-risk technology can be accelerated by following the recommendations offered. This conclusion is based on the overwhelming evidence that their are multiple impediments to high-payoff low-risk technologies that the user needs to overcome the numeric superiority of the threat and there are expediters that are not being fully utilized in a transfusion role.

These expediters include many organizations and processes that can be used for transfusion but were designed for other purposes. One can transfuse technology by understanding, linking, and using existing processes; however, if one wants to capitalize on mature technology in a much more effective way he should network the existing processes/organizations into a decentralized whole, guided when needed by a central organization whose "in charge." The synergistic interaction of the players, guided by this central organization will more than pay for the investment.

RECOMMENDATIONS

The primary recommendation from this report is the chartering and manning of an organization to act as a core in a technology transfusion network that would advocate and link (integrate) transfusion efforts in a systematic way across the Air Force. Each organization that is key to transfusing technology should become a node on that network and chartered and trained to perform their functions. The closer the interpersonal relations of the network approach a single matrixed organization without organizational boundaries, the better.

The rest of this section will sketch more of the details of the network as well as provide some related recommendations on how to improve the transfusion process. Refer to the pages listed after the recommendation for expanded explanations.

1. Charter an organization with at least a full time division to become the core of a network of key players that can transfuse technology across the Air Force (see page 27-32 for candidates and Appendix for more details). Other organizations should be added as nodes to the network in a modular fashion to provide ease of implementation, and flexibility and efficiency in execution. The network should use existing organizations and

processes as much as possible but should not be constrained to just them. Some general guidance as to how the core team might be organized follows (page 27-30).

a. This organization should have the clout to carry out its charter. The clout may best be derived from a general officer steering group representing the using, acquiring, and logistics communities. Additional clout can come by changing such regulations as AFR 80-1.

b. It is essential the network "market" the technologies in such a way that is perceived as unbiased and beneficial to the participants. The above mentioned general officer steering group coupled with a reporting chain through the Air Staff/DOD should enhance this effort.

c. Organizations within the network should be trained and chartered to accomplish their tasks. Training should be mostly awareness type with the exception of the organization's coordinator (technology gatekeeper). Part of the training should be to facilitate communication to help ensure timely feedback between the participants.

d. The other services (probably through the JLC) should become nodes on the network to coordinate and share joint assets.

e. Consider contracting out parts of the organization as is done for NASA's Technology Utilization Program. If this option is used, it is essential that the advocating (marketing) role still be accomplished, preferably organically.

f. Advocate the remaining recommendations in this chapter and organize/run the "TECHFUSION" effort (recommendation three) and the technology transfusion plans (recommendation four).

2. Define transfusion, transfer, insertion in JCS Pub 1 and disseminate to industry (page 2).

3. An ongoing "TECHFUSION" effort, similar to "TECHINSERT" should be started to develop a prioritized compendium of low-risk high-return technologies that are ready for insertion (pages 23-24).

4. Develop Technology Transfusion Plans from a validated list of technologies (TECHFUSION list). These should plan for the transfusion of technology from its first insertion on a system through subsequent insertions. It should target weapon systems in the inventory and in development. The various transfusion expediters should be specified by system and signed off by the

appropriate decision makers. In all cases the user must be involved through out the process as the primary customer (page 21-22).

5. Technology requirements should normally be documented in PMDs and SOWs in performance terms unless the desired technology is known, then it should be specified the contractor use the technology or justify why not (page 22-23).

6. MIL-SPECs should be made flexible enough to respond in a timely manner to changes in standards due to technology. Once a technology has been proven acceptable and the first waiver to the SPECs granted, the system should process additional waivers easily (page 24-25).

7. Consider making technology transfusion funds self-generating using either a revolving fund or a contractor administered one. Self-generating funds should help insert technologies that promise a significant monetary return. For technologies that yield other than monetary returns, funds would have to be taken out of the revolving account's "profits" or subsidized from some other source like the beneficiary of the technology (page 25-26).

8. Incentives should be enhanced and disincentives and risk reduced for the participants, who use, find, fund, and integrate the technology. The methods to do that can range from monetary rewards and letters of appreciation to top management support (page 24-25).

A FINAL WORD

The United States (US) has long recognized we need technology to overcome the numeric superiority of the threat. To that end the US has pushed the state of the art into our developing weapon systems, then, often after the first application put the technology on the shelf. In the mean time, the Soviets are stealing it and the Japanese are copying it, while our O&M costs are too high, our depots too inefficient, and worst of all our operators and the maintainers in field make do with what they have. We need a technology clearing house to take the low-risk high-return technology off the shelf and insert it into our developing and especially existing systems. Hopefully, we will recognize this is not so much a cost as it is a real opportunity to invest our limited resources. An investment we need not only to save the money needed to keep our system going, but most of all, to give the warrior in the field the combat capability he needs for the Air Force and the Department of Defense to accomplish their mission of protecting this nation and democracy around the world.

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APPENDIX

TECHNOLOGY TRANSFUSION CORE TEAM MANPOWER

Personnel	Interface/Function
2	Technology Awareness
1	5 Air Logistics Centers
1	5 Product Divisions
2	14 Laboratories
2	Industry Interface
2	Joint Activities (JLC, DARPA, etc.)
1	Academia
1	Funds
1	Analysis
1	Automated Data Processing
1	Maintenance NCO - Sanity Check
1	Secretary
1	Chief

17 positions

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